Closing the gap between industry and consumers in sunscreen application

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Abstract

While sunlight is physiologically important for Vitamin D3 production, excess sun exposure is linked to sunburns and skin cancers. Sun-protective behaviours are thus warranted year-round, with sunscreens playing a critical role in protecting the skin from ultraviolet radiation. The current method of quantifying the extent of protection offered by sunscreens relies on sun protection factor (SPF). Manufacturers assume evenly spread sunscreen with an application thickness of 2mg/cm^2 when determining SPF values for their products. These are unfortunately not held in real-life, with consumers applying significantly less quantities of sunscreen. Such discrepancy between industry and consumers could lead to a false sense of security, and ultimately decreased skin health of the public. By bridging the gap through both consumer- and industry-directed approaches, the morbidity, mortality, and healthcare expenditures associated with excess sunlight exposure could be reduced. Specifically, consumers should be recommended to apply sunscreens with higher SPF values. Public health initiatives could also target to increase the general awareness in the inadequacy of practical sunscreen application trends of consumers. Industries could gradually alter their testing standards to preserve reproducibility while becoming closer to practical settings.

The Goldilocks of sunshine: getting just the right amount

Sun exposure is like a double-edged sword. Physiologically, sun exposure is linked to Vitamin D3, also known as the "sunshine vitamin".[1] During its synthesis, sunlight is required to convert 7-dehydrocholesterol to the precursor form of Vitamin D3. The beneficial effects of Vitamin D3 on calcium metabolism and immune system activation render it crucial to life. On the other hand, too much sun exposure is accompanied by sunburns and an increased risk of cancers of the skin.[1] The latter include not only non-melanoma skin cancers (basal and squamous cell carcinomas), but also malignant melanoma (MM). In particular, MM poses a public health concern, with its incidence having increased at a faster rate than any other cancer in the past 30 years.[1]

In this commentary, we will explore healthy sun behaviours to minimize adverse consequences of excess sun exposure, with a focus on sunscreen application. Discrepancies in application trends between industrial testing and practical application settings are discussed, and their consequences. We will explore previous efforts of mitigating this gap, and contend for future strategies aimed at bringing manufacturers and consumers closer.

Sun-protective behaviours are warranted year-round and beyond the beach

UV rays are the main culprits for the adverse health consequences associated with too much sunshine. They are categorized into UVA or UVB subtypes. While both are associated with increased risks of skin cancer, UVB is also responsible for sunburns.[2] In Canada, the most hazardous times for UV exposure from natural sunlight are between 11 a.m. to 3 p.m..[3] Nevertheless, protection from sun exposure is a year-round commitment. UV rays deserve attention even on cloudy days, warranting sun protection in daily life beyond the beach.[3]

To avoid excessive UV radiation, the Centers for Disease Control and Prevention recommends staying in the shade, and using clothing items and sunglasses to protect exposed areas.4 These strategies are especially important in babies, whose skin is far more sensitive than their adult counterparts.[2] In particular, babies under six months of age are recommended to not use sunscreens, limiting their options to avoidance of UV radiation.[5]

In the general population, the prevalence of outdoor activities warrants the use of sunscreen on top of avoidance strategies when sun exposure is inadvertent. Health Canada advises using broad-spectrum sunscreens with sun protection factors (SPF) of at least 30.[2] Broad-spectrum products offer protection for both subtypes of UV radiation. Sunscreen should be applied at least 15 minutes prior to sun exposure, and reapplied every two hours.[2] Consideration for greater quantity or specific "water resistant" and "sport" types should be made when swimming or rigorous sport activities are involved.[2]

Just as the use of sunscreen is important for protecting one's skin, so is its proper application. Generous amounts should be applied to areas of the body that are potentially exposed without

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adequate coverage by clothing.[2] These include the head and neck, as well as exposed skin in the limbs. In general, adults require 35 mL or seven teaspoons of sunscreen to cover their exposed skin. One teaspoon is recommended in each of the following anatomical sites: head and neck, front torso, back, and one arm or leg.

Well-intended mistakes in sunscreen application

The potency of sunscreens to protect against UV radiation is quantified using the SPF.[6] SPF is calculated using the minimal erythema dose (MED), which is defined as the lowest dose of UV radiation required to evoke erythema following 24 hours of exposure.[7] The ratio of MED for sunscreen-protected versus bare skin is used as follows:

$$\text{SPF} = \frac{\text{MED with sunscreen}}{\text{MED without sunscreen}}$$

SPF is then interpreted with regards to the length of time that consumers are protected against UV exposure. For example, a hypothetical consumer may experience erythema after 10 minutes of sun exposure in bare.[9] When he or she applies sunscreen of SPF 15, this amount of time is extended to around 150 minutes.[9] Special attention should be paid to family history of skin cancers, and skin types as fair-skinned individuals are at greater risk for UV damage.[3]

When testing the SPF for a given product in industrial settings, certain assumptions are made. Sunscreen is applied at a thickness of 2mg/cm^2, and assumed to be applied evenly on the skin.[8] These assumptions are held when testing a variety of sunscreen products, as backed by the American Food and Drug Administration, and the International Organization for Standardization.[8]

Neither of these assumptions are consistently respected in real-life settings. Studies have repeatedly found sunscreen application thickness for consumers to be far less than the recommended 2mg/cm^2. For instance, a 2014 review by Petersen and Wulf found that consumers applied only 20-50% of the recommended application thickness.[8] The cosmetic acceptability of sunscreens can influence the quantity used, as Diffey and Grice found that the quantity of physical sunscreens used was on average two-thirds of that for chemical sunscreens.[10] While the two types of sunscreen differ in their ingredients, physical sunscreens are deemed to be less cosmetically acceptable by consumers.[10]

Sunscreen application is also very uneven, with certain areas of the body receiving far less coverage than others.[11] An investigation of Danish beachgoers by Heerfordt et al. found that consumers apply more sunscreen to the forehead, abdomen, and chest compared to less covered areas of upper back, as well as posterior thighs and legs.[11] This difference was the most exaggerated between the forehead and upper back, with the former anatomical region receiving 12 times more sunscreen than the latter.[11] The authors cited reduced accessibility as a factor for sunscreen application in the back, in that consumers found it more challenging to reach the back when applying sunscreen alone.[11]

Identifying the gap between manufacturers and consumers

Currently, there appears to be multiple discrepancies between industrial and practical environments for sunscreen application. These may have profound consequences. Returning to our hypothetical consumer, he or she would expect to be protected against UV radiation for approximately 150 minutes after applying sunscreen of SPF 15. This expectation will guide the consumer in keeping track of time, so that he or she will seek shade or reapply sunscreen afterwards.

Nevertheless, the SPF value is only accurate when assumptions made in the industrial setting are followed in terms of sunscreen application thickness and evenness. When sunscreen is not applied as instructed the SPF value is unreliable and, as shown by consumer studies, oftentimes can be lower than indicated. To further complicate matters, the relationship between sunscreen application thickness and SPF is not fully elucidated and may be exponential.[12] This means that an application thickness of 1mg/cm^2 (half of the recommended guideline used in industrial testing) will not result in halving of SPF. Instead, SPF will fall by the square root.

Indeed, evenly applying sunscreen of 2mg/cm^2 is critical for consumers to be accurate in their expectation of how much sun exposure time is afforded by their sunscreens. Failure to do so may result in overestimation of the extent of protection, such that consumers may expose themselves for longer amounts of UV exposure time. The price of overstaying their time in sunshine may include not only sunburns, but also increased potentials for skin cancers.

Manufacturers and consumers: Speaking the same language

Closing the gap between industrial standards and everyday usage of sunscreen may encourage consumers to use sunscreens as intended by manufacturers. By providing consumers with accurate information in the degree of protection provided by their products, the skin health of general public may improve. The latter may lead to decreased morbidity, mortality, and health expenditures associated with excess UV exposure.

What has been done so far?

Previous efforts have been made to increase the sunscreen application thickness among consumers to match that of industry. A study by Azurdia et al. attempted to educate patients with dermatological conditions on their sunscreen application trends.[13] Educational efforts were comprised of in-clinic visits, where deficiencies in patients' application of sunscreen were discussed. Using fluorescent spectroscopy, the patients' application thicknesses of sunscreen before and after the intervention were determined.[13] Compared to the baseline of 0.11mg/cm^2, sunscreen application thickness significantly increased to 0.82mg/cm^2 and 1.13mg/cm^2 at two weeks and six months after the program, respectively.[13]

In 2018, the aforementioned paper by Heerfordt et al. evaluated the double application technique of sunscreen.[11] 32 healthy volunteers were tested for the quantity of sunscreen used following single and double applications. With the first application, participants applied sunscreen at a thickness of 0.6mg/cm^2 and missed a median of 20% of body surface.[11] After double application, the sunscreen thickness increased to 1.1mg/cm^2 while the missed body surface decreased to 9%.[11] Individually, volunteers applied between 13-100% more sunscreen after the second application compared to one application alone.[11] Unfortunately, an uneven nature of sunscreen application remained even after double application, as previously mentioned.[11]

Next steps: What could be done?

Although both of the above studies are promising in increasing the application thickness of sunscreen, neither were capable of reaching an evenly spread sunscreen at 2mg/cm^2. These results indicate that attempts to change consumer behaviours do improve the application thickness, but they can be combined with further measures.

For starters, consumers can be recommended to apply sunscreens of higher SPF value. Current recommendations from the Government of Canada and American Academy of Dermatology Association encourage consumers to use sunscreens with SPF of 30 or higher. [2,14] While this may be adequate with the ideal sunscreen application pattern, practical application trends among consumers may warrant further protection. Instead of 30, guidelines could be altered to recommend consumers to use products with higher SPF values, such as 50, 80, or even 100. By using sunscreens of higher protective abilities, the under-application among consumers may be counteracted.

Furthermore, consumer awareness in the discrepancy between practical and industrial application trends of sunscreen could be increased through public health initiatives. Previous educational efforts had aimed to alter the sunscreen application behaviour of a limited group of study population to apply greater quantities of sunscreen. While they may not have been sufficient to meet the industrial criteria of 2mg/cm^2, raising public awareness with regards to the gap that blatantly exists between consumers and manufacturers could be worth exploring. As of present, consumers may be misled by their perception in the degree of protection offered by sunscreens. Efforts can be made to break this overestimation of sunscreen capacity, and to bring the expectations of consumers closer to reality. These programs should target all ages, and deliver the reality in the inadequacy of sunscreen application among consumers. Consequences of UV damage, including sunburn and skin cancers, should also be included to increase awareness of the grave implications associated with excess sun exposure.

Examples of such initiatives could include posters and free informational brochures distributed to the public at beaches, parks, schools, and other public places where many individuals gather and are potentially exposed to UV radiation. These could be supplemented with advertisements on social media and television to reach a greater target audience. Public health experts could be involved in designing these initiatives, and programs could in turn be assessed through randomized control trials to continuously monitor performance and determine avenues for improvements.

Finally, the gap could also be tackled from the industrial perspective. Perhaps sunscreen manufacturers could also be included in the picture. Application thickness of 2mg/cm^2 was originally selected as it was associated with the greatest reproducibility and lowest variability in industrial testing results.[8] This allows manufacturers to be more confident in their SPF reporting, which in turn allows consumers to directly compare multiple products before making an informed purchase. And yet, generalizability may be low as thicknesses of 2mg/cm^2 are not being followed by consumers. By requiring manufacturers to slowly change their industrial testing standards, the SPF value written on the bottle of sunscreens could reflect the true extent of protection. Manufacturers could be mandated to research the application thickness with satisfactory reproducibility, while remaining more aligned with the practical values used by consumers. To provide incentives for the manufacturers, public health organizations could fund some of these studies. This is naturally more of a long-term goal, and other strategies ought to be used in the interim to promote better public skin health.

Role for health care providers

As health advocates, health care providers have a responsibility to speak for the improved health of the general public. By calling the government for actions in changing consumer recommendations, adopting public health initiatives, and requesting manufacturers to follow suit, we may be able to close the gap in sunscreen application.

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